1. Doubling a cell's radius changes its surface-to-volume ratio how?

   ☐ It stays the same

   ☐ It quarters

   ☐ It halves (SA/V = 3/r)

   ☐ It doubles

2. For K^+ (140 mM in, 5 mM out), E_K at 37 °C is about –

   ☐ −67 mV

   ☐ −45 mV

   ☐ +67 mV

   ☐ −89 mV

3. Why is there a lagging strand?

   ☐ The template strands are antiparallel and polymerase builds only 5′→3′

   ☐ The lagging strand is copied from RNA

   ☐ One strand is damaged and must be repaired first

   ☐ Helicase unzips only one strand at a time

4. Why are codons triplets?

   ☐ Ribosomes have three binding sites

   ☐ DNA has three kinds of base

   ☐ Two bases give only 16 codons, fewer than 20 amino acids; three give 64

   ☐ There are 3 stop codons

5. How does an enhancer differ from a promoter?

   ☐ It works only on the template strand

   ☐ It is always inside the first exon

   ☐ It can act from far away, in either orientation, by DNA looping

   ☐ It codes the transcription factor

6. One receptor activates 20 G-proteins; each turns on one cyclase making 1000 cAMP per second for 3 seconds. How many cAMP molecules result?

   _____

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_____ doublings

8. A spherical cell is 60 µm across. What is its surface-to-volume ratio, in "per µm"?

   _____ per µm

9. Ca^{2+} is 100 nM inside and 1.0 mM outside. What is E_{Ca} at 37 °C?

   _____ mV

10. A 1.2×10^8 bp chromosome must be copied by forks moving at 50 bp/s each. With 2 forks per origin, how many origins are needed to finish in 1 hour of pure copying?

    _____ origins

1. **It halves (SA/V = 3/r)**

   Area grows as r^2, volume as r^3, so SA/V = 3/r: doubling r halves the ratio. This is the argument that caps cell size.

2. **−89 mV**

   E = 61.5 × log10(5/140) = 61.5 × (−1.447) = −89.0 mV.

3. **The template strands are antiparallel and polymerase builds only 5′→3′**

   Antiparallel templates and a 5′→3′-only enzyme mean one strand must be made in short pieces, backwards from the fork.

4. **Two bases give only 16 codons, fewer than 20 amino acids; three give 64**

   Two bases cannot name 20 amino acids; three give 64 with spare codons spent on third-base degeneracy, which tolerates damage.

5. **It can act from far away, in either orientation, by DNA looping**

   Enhancers loop to the promoter from up to about 100 kb away, in either orientation; the promoter sits at the start site.

6. **60000**

   20 × 1000 × 3 = 60 000 molecules from one hormone molecule.

7. **30 doublings**

   $2^{30} = 1.07 \times 10^9$. A tumour you can just detect has been growing silently for years, which is why screening intervals matter.

8. **0.1 per µm**

   r = 30 µm, so SA/V = 3/30 = 0.1 per µm: a third of a 20 µm cell's 0.3.

9. **123 mV**

   The ratio is 1.0 mM / 100 nM = 10^4, so E = (61.5/2) × 4 = 123 mV. Forget z = 2 and you get 246 mV.

10. **333 origins**

    Each origin copies 100 bp/s, so 3.6×10^5 bp per hour. 1.2×10^8 / $3.6 \times 10^5 \approx 333$ origins.